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$$d^2s/dt^2 = -g\sin\phi - k(ds/dt)^2 \text{.....}(4).$$

Let v_1 = velocity of particle at any point; then (4) becomes

$$d^2s/dt^2 = -g\sin\phi - kv_1^2 \text{.....}(5),$$
$$v_1^2/\rho = g\cos\phi \text{.....}(6).$$

But $u = v_1\cos\phi$ and $\rho = -ds/d\phi$. $\therefore$ (5) and (6) become

$$du/dt = -kv_1^2\cos\phi \text{.....}(7),$$
$$v_1(d\phi/dt) = -g\cos\phi \text{.....}(8).$$

$$\therefore \frac{du}{d\phi} = \frac{k\,v_1^3}{g} = \frac{k}{g}u^3\sec^3\phi \text{.....}(9).$$

At the origin, $u = v\cos\alpha$. Integrating (9) we get

$$\frac{1}{v^2\cos^2\alpha} - \frac{1}{u^2} = \frac{k}{g}(A_\phi - A_\alpha) \text{.....}(10).$$

Where $A_\phi = \int_0^\phi 2\sec^3\phi d\phi$, $A_\alpha - A_\phi = 2\int_\phi^\alpha \sec^3\phi d\phi$

$$= \tan\alpha\,\sec\alpha - \tan\phi\,\sec\phi + \log\left(\frac{\tan\alpha + \sec\alpha}{\tan\phi + \sec\phi}\right).$$

bstituting in (10) we get

$$\frac{k}{g}\,v^2\cos^2\alpha\left[\tan\alpha\,\sec\alpha - \tan\phi\,\sec\phi + \log\left(\frac{\tan\alpha + \sec\alpha}{\tan\phi + \sec\phi}\right)\right] = e^{2ks} - 1,$$

for the intrinsic equation to the curve.

MISCELLANEOUS.

148. Proposed by F. P. MATZ, Ph. D., Sc. D., Reading, Pa.

Given $\sin 3\phi + \cos 3\phi = m$.............(1), and $\cos\phi - \sin\phi = x$...............(2), to find x in terms of m.

Solution by J. SCHEFFER, A. M., Hagerstown, Md.

Since $3\sin\phi - 4\sin^3\phi = \sin 3\phi$ and $-3\cos\phi + 4\cos^3\phi = \cos 3\phi$, we have $4(\cos^3\phi - \sin^3\phi) - 3(\cos\phi - \sin\phi) = m$, or $(\cos\phi - \sin\phi)[4(\cos^2\phi + \cos\phi\,\sin\phi + \sin^2\phi) - 3] = m$.

Since $\cos\phi - \sin\phi = x$, $2\sin\phi\,\cos\phi = 1 - x^2$ and therefore $2x^3 - 3x + m = 0$.

Also solved by A. H. Holmes, and the Proposer.